Blood Pressure Measurement

Pediatric

Standardization Protocol

HEART DISEASE &
STROKE PREVENTION PROGRAM
UTAH DEPARTMENT OF HEALTH

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INTRODUCTION

There are many advances in the detection, evaluation, and management of high blood pressure (hypertension), in children and adolescents. Research and a national database survey have shown that primary hypertension is detectable in children and adolescents and occurs commonly. The long-term health risks for hypertensive children and adolescents are substantial. Early detection and treatment is the best way to make sure other health problems don't develop as a result of increased blood pressure.

BLOOD PRESSURE OVERVIEW

Key Abbreviations

BP= Blood Pressure
SBP= Systolic Blood Pressure
DBP= Diastolic Blood Pressure
JNC7= Seventh Report of the Joint National Committee on the Prevention, Detection, Evaluation, and Treatment of High Blood Pressure

CVD= Cardiovascular Disease
BMI= Body Mass Index
ABPM= Ambulatory Blood Pressure Monitoring
ACE= Angiotensin-converting enzyme
β-blockers= beta-blockers
LVH= Left ventricular hypertrophy

Definitions

Blood Pressure
Measurement of the force exerted by flowing blood against the walls of the arteries.

Systolic Blood Pressure
Measurement of the pressure when the heart is contracted (systole). The systolic pressure indicates the maximal amount of work/force the heart has to perform with each stroke in order to move blood through the arteries. It also indicates how compliant the arteries are in order to accommodate blood; it indicates how "elastic" they are.

Diastolic Blood Pressure
Measurement of the pressure when the heart is relaxed (diastole). The diastolic pressure indicates the amount of pressure the heart has to overcome in order to generate the next beat. During diastole, blood circulates through the heart own arteries. If the pressure is too high during this phase of the stroke cycle, the hearts vessels cannot expand and cannot accommodate enough blood. The heart then suffers from not enough circulation to supply itself with oxygen and nutrients. This could lead to a heart attack.

Hypertension
A persistent elevation of either diastolic or systolic blood pressure.

Essential Hypertension (primary)
High blood pressure with no identifiable cause.

Secondary Hypertension
Hypertension with a known cause.
Identifiable causes:

- Sleep apnea
- Drug-induced or related causes
- Chronic kidney disease
- Primary aldosteronism
- Renovascular disease
- Chronic steroid therapy and Cushing's Syndrome
- Pheochromocytoma
- Coarctation of the aorta
- Thyroid or parathyroid disease

Korotkoff Sounds
Distinct blood pressure sounds were first described by a Russian physician named Korotkoff. He identified the following five phases in blood pressure:

First Phase	A clear tapping sound; the onset of the sound of two consecutive beats is considered systolic blood pressure.
Second Phase	The tapping sound, followed by a murmur. Usually 10 - 15 mm Hg below first phase and lasting for 14 - 20 mm Hg. In some instances, such as when the cuff is inflated too slowly, part or all of the sounds of this phase may be absent, resulting in a period of silence known as an auscultatory gap.
Third Phase	A loud, crisp tapping sound.
Fourth Phase	Abrupt, distinct muffling of sound, gradually decreasing in intensity.
Fifth Phase	The disappearance of sound, considered diastolic blood pressure.

Characteristics of hypertension:

- There are NO characteristic signs or symptoms.
- There is NO cure. Therapy and/or lifestyle modification can control and in many cases prevent complications.
- Uncontrolled high blood pressure is target organ damage to the heart, brain, kidney and eyes.
- High blood pressure can only be detected by **ACCURATE BLOOD PRESSURE MEASUREMENT!**

Accurate Blood Pressure Measurement:

Blood pressure values are used for diagnosis, determination of prognosis and for initiating, evaluating, and discontinuing treatment. With such widespread interest in and reliance on the procedure of blood pressure measurement, standardization of all personnel and equipment is necessary to minimize the major sources of error, which contribute to variation in blood pressure measurement, and may adversely influence clinical treatment decisions. This standardization should include: selection of quality blood pressure measuring equipment, proper maintenance of equipment, accuracy checks (calibration), and instruction and accreditation in the measurement techniques recommended by the American Heart Association and The National High Blood Pressure Coordinating Committee of all personnel directly involved in blood pressure measurement.

DEFINING HYPERTENSION IN CHILDREN AND ADOLESCENTS

Defining childhood hypertension is based on the normative distribution of blood pressure in healthy children.

- Normal blood pressure is defined as either systolic or diastolic blood pressure below the 90th percentile for age and sex.

- Hypertension is defined as average systolic blood pressure and/or diastolic blood pressure that is ≥95th percentile for gender, age, and height on 3 or more occasions.

- Prehypertension in children is defined as average systolic blood pressure or diastolic blood pressure levels that are greater than or equal to the 90th percentile but less than the 95th percentile.

- As with adults, adolescents with BP levels greater than or equal to120/80 mmHg should be considered prehypertensive.

- A patient with BP levels greater than the 95th percentile in a physician's office or clinic, who is normotensive outside of the clinical setting, has "white coat syndrome." White coat syndrome refers to a higher than normal blood pressure when one visits their doctor. Ambulatory blood pressure monitoring (ABPM) is usually required to make that diagnosis.

- Elevated blood pressure in childhood often correlates with hypertension in early adulthood.

- The findings of a single elevated reading does not constitute a diagnosis of hypertension, but does indicate the need for further evaluation including three repeated measurements over time. Children with severely elevated readings should be evaluated immediately.

- The evaluation of hypertensive children should include assessment for additional risk factors.

- Sleep apnea and overweight are strongly associated with high blood pressure, therefore a sleep history should be obtained.

- Essential (primary) hypertension is identifiable in children and adolescents. It is usually characterized by mild stage 1 hypertension and a positive family history of hypertension or cardiovascular disease (CVD).

- Children with essential hypertension tend to be overweight and frequently have some degree of insulin resistance (prediabetic condition).

- Secondary hypertension is more common in children than in adults.

- You should collect a thorough medical history to rule out potential causes. The possibility that some underlying disorder may be the cause of the hypertension should be considered in every child or adolescent who has an elevated blood pressure.

- Once hypertension is confirmed, blood pressure should be measured in both arms and a leg.

- Due to the strong link between overweight and high blood pressure, calculate a BMI as part of the physical examination.

MEASUREMENT OF BLOOD PRESSURE IN CHILDREN AND ADOLESCENTS

- The recommended method of blood pressure measurement is auscultation. Auscultation is a method used to "listen" to the sounds of the body during a physical examination by using a stethoscope.
- Accurate measurement requires the appropriate cuff size for the child's upper arm.
- Children who are 3 years of age and older who are seen in a medical setting should have their blood pressure measured.
- Blood pressure measurements that are obtained by oscillometric devices (automatic instruments) that exceed the 90th percentile should be repeated by auscultation
- Confirm elevated blood pressure on repeated visits before diagnosing a child as hypertensive.

BP Measurement Technique:

TECHNIQUE	RATIONALE
Consider the following environmental and biological factors: ▪ Warmth ▪ Quiet ▪ Rest five minutes prior to measurement ▪ Smoking, caffeine, alcohol or drugs (birth control pills, decongestants, or diet pills) ▪ Non-threatening atmosphere ▪ Confidentiality ▪ Time of day ▪ Previous activity ▪ Emotional state ▪ Pubescent females	Proper preparation of the child is essential for accurate blood pressure measurement. Environmental and biological factors do alter the blood pressure. Vasoconstrictive substances may increase blood pressure. Adolescents may not want their peers to see them, as they can be easily embarrassed. These patients should be measured in a private or screened area. **Have they just come from a P.E. class or had a traumatic procedure, e.g., immunization?**
Explain procedure fully. Demonstrate the procedure on the parent or sibling to show child it is painless. Use of hand puppets to demonstrate can be an effective method as well.	Great care should be taken with first measurement of a small child or infant. Sometimes that is the only measurement you'll get, without tears, tantrums, etc.
A young child can sit on a parent's lap with the parent supporting the arm in the correct position.	
Select appropriate cuff size and apply snugly around the right arm so that it's lower edge is above the antecubital fossa, allowing room for placement of the bell of the stethoscope lightly over the brachial artery.	It is necessary to have a variety of cuff sizes to correspond to limb size. A selection of appropriate cuff sizes is of critical importance if accurate measurements are to be obtained.

TECHNIQUE	RATIONALE
Dimensions of Appropriate Cuff Size Cuff Name Width (cm) Length (cm) Newborn 2.5-4.0 5-9 Infant 4-6 11.5-18 Child 7.5-9 17-19 Adult 11.5-13 22-26 Large Adult 14-15 30.5-33 Adult Thigh 18-19 36-38 The appropriate cuff size should be selected according to build and weight of the child, **NOT ACCORDING TO AGE.**	Cuffs that are too narrow will produce erroneously high blood pressure readings. The cuff should be wide enough to cover about 80% of the upper arm, between the top of the shoulder and the elbow, but leaving enough room to place the bell of the stethoscope over the brachial artery at the antecubital fossa and also not obstructing under the arm (axilla), (see diagram in appendix.) When the cuff is applied to the arm, the end of the cuff should fall within range marked on the inside of the cuff. If a cuff that is too short is used, a false high reading will be obtained. Both the width and the length of the cuff are important. A pediatric stethoscope may be considered, because of the smaller bell and diaphragm. If the standard stethoscope is used, the bell, not the diaphragm should be used.
Locate radial pulse.	
Inflate cuff slowly until pulse obliterates. Continue to inflate cuff rapidly to 20 mm Hg above the point where the radial pulse disappeared (see pulse obliteration method explanation in appendix).	The pulse obliteration method (see appendix) is used with children and adolescents as it is with adults.This method eliminates the problem of auscultatory gap(temporary disappearance of second phase blood pressure sounds).
Release pressure within cuff at a rate of 2 mm Hg/second.	Deflating a cuff too rapidly or slowly will give inaccurate readings.
Record the onset of two consecutive sounds as systolic pressure and the fifth Korotkoff phase or disappearance of sound as diastolic. *Measurement:_____/_____/_____ 1st phase systolic 4th phase 5th phase diastolic e.g., 110/60 or 110/70/0 Record - limb: Rt. (right arm) position: (sitting) cuff size: (infant, child)	Fourth Korotkoff Phase: The tap becomes a low-pitched muffle of decreasing intensity. The Fourth and Fifth Phase frequently occur simultaneously in children and often there is no fifth phase at all, with sounds audible to zero.

Summary of Best Conditions for Measuring Blood Pressure:

- Patient should not smoke or drink caffeine within 1/2 hour of the blood pressure measurement.
- Have patient sit for five minutes before measurement.
- Patient's upper arm should be at heart level. Each centimeter above or below can produce an error of 0.8 mm Hg.
- Use correct cuff size.
- Use right arm.
- Inflate cuff as rapidly as possible to 20 mm Hg above pulse obliteration for children and adolescents.
- Deflate cuff at 2 mm Hg/second.
- If sounds are faint and the blood pressure measurement needs to be repeated, wait at least 30 seconds before inflating a second time.
- View aneroid from directly in front and no further than three feet away.
- View mercury with eye at the level of the meniscus no further than three feet away. Sphygmomanometer must be vertical.
- Patient's feet must be flat on the floor with legs uncrossed.
- Never take a blood pressure over clothing.
- Never place the stethoscope under the cuff.
- All readings are rounded up to the nearest even digit.
- Systolic reading is the point at which the initial tapping sound is heard for at least two consecutive beats.
- Diastolic reading is 2 mm Hg below the last sound heard, which is the disappearance of sound.
- Diastolic reading for children 0-13 years is now the Fifth Korotkoff Phase.
- Remember to consider and record all stressors on the patient such as temperature, anxiety, full bladder, smoking, food or drink, activity, etc.

If the sounds were **faint**:

1) Recheck the placement of stethoscope over the brachial artery.
2) Eliminate extraneous noise.
3) Ask patient to raise his or her arm for 10-15 seconds, then inflate the cuff more rapidly to peak inflation level while arm is elevated, lower arm and proceed with measurement.

Blood Pressure Measurement on Lower Extremities

This measurement is indicated in subjects that have certain types of obstructive aortic disease, coarctation of aorta or arm amputation. Use a large cuff for infants and children. The subject should be laying face down, the cuff applied with the center of the inflatable bladder over the posterior aspect of the mid-thigh. The head of the stethoscope is placed over the popliteal fossa (area behind the knee). Monitor the Korotkoff sounds as the pressure in the bladder is lowered just as is done in the arm. In a situation where the subject is unable to lie face down, a measurement can be taken with the subject lying on their side or back with their knee slightly flexed so that the stethoscope can be placed over the popliteal pulse. While diastolic pressure in the legs is generally similar to that in the arms, systolic pressure may be 20 to 30 mm Hg higher.

Reading Blood Pressure Tables and Growth Charts

Blood pressure standards are based on gender, age, and height. They provide a precise classification of blood pressure according to body size.

- Use the appropriate NCHS (National Center for Health Statistics) percentile chart for girls or boys located on pages 13 & 14. Determine the child's height (stature) and age.
  - ✓ Find the child's age at the bottom of the chart.
  - ✓ Follow the age line vertically up the chart to the intersection of the line for the actual height (stature) on the left side of the chart.
  - ✓ Determine the height percentile by matching the range with the percentiles listed on the right side of the chart.

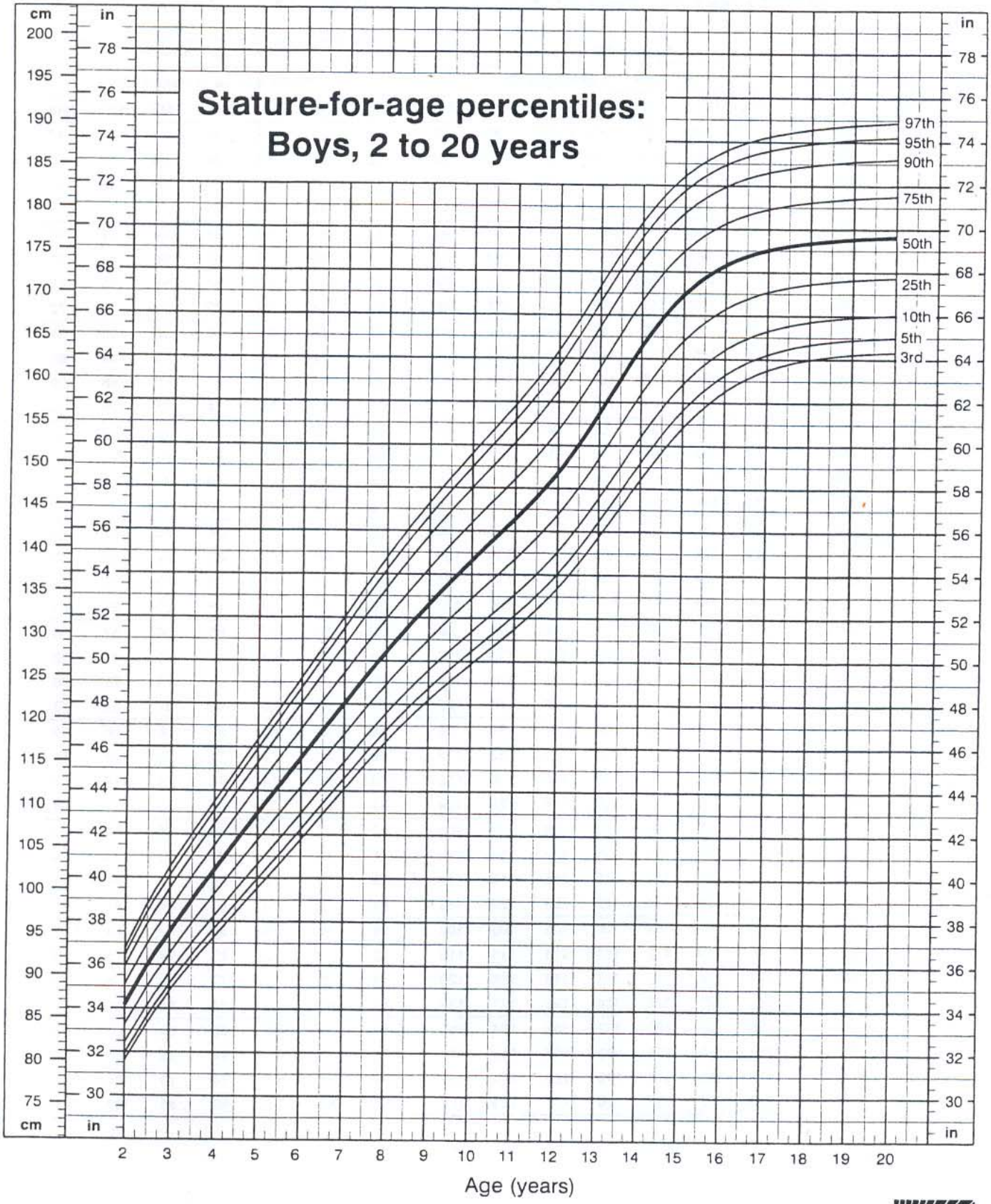
- Measure the child's blood pressure and record the systolic and diastolic pressure (5th sound).

- Use the percentile charts appropriate for child's gender located on pages 15-19.
  - ✓ Find the child's age on the left side of the chart.
  - ✓ Find the child's height percentile on the top of the chart.
  - ✓ Find the intersection of the height percentile and age.
  - ✓ This value will help you determine if the child's systolic blood pressure is above the 90th or 95th percentile.
  - ✓ Diastolic values are located to the right of the systolic. Repeat the same process.

- Determine blood pressure classification of child; make appropriate recommendation for follow-up measurements.

Example: The blood pressure measurement of a 10-year-old female is 90/62 mm/Hg. She is 55 inches tall. Her height percentile using the NCHS Chart is the 50th percentile. Next, using the 90th and 95th Percentile Chart for girls, the child's age of 10 is found, and next her height percentile (in this case, 50th). The value show on the chart for this age and height percentile is 115 for systolic and 74 for diastolic. Since her blood pressure is 90/60 mmHg., it is well below the 90th percentile. Therefore she would be classified as having Normal Blood Pressure.

CDC Growth Charts: United States



Published May 30, 2000.

SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).

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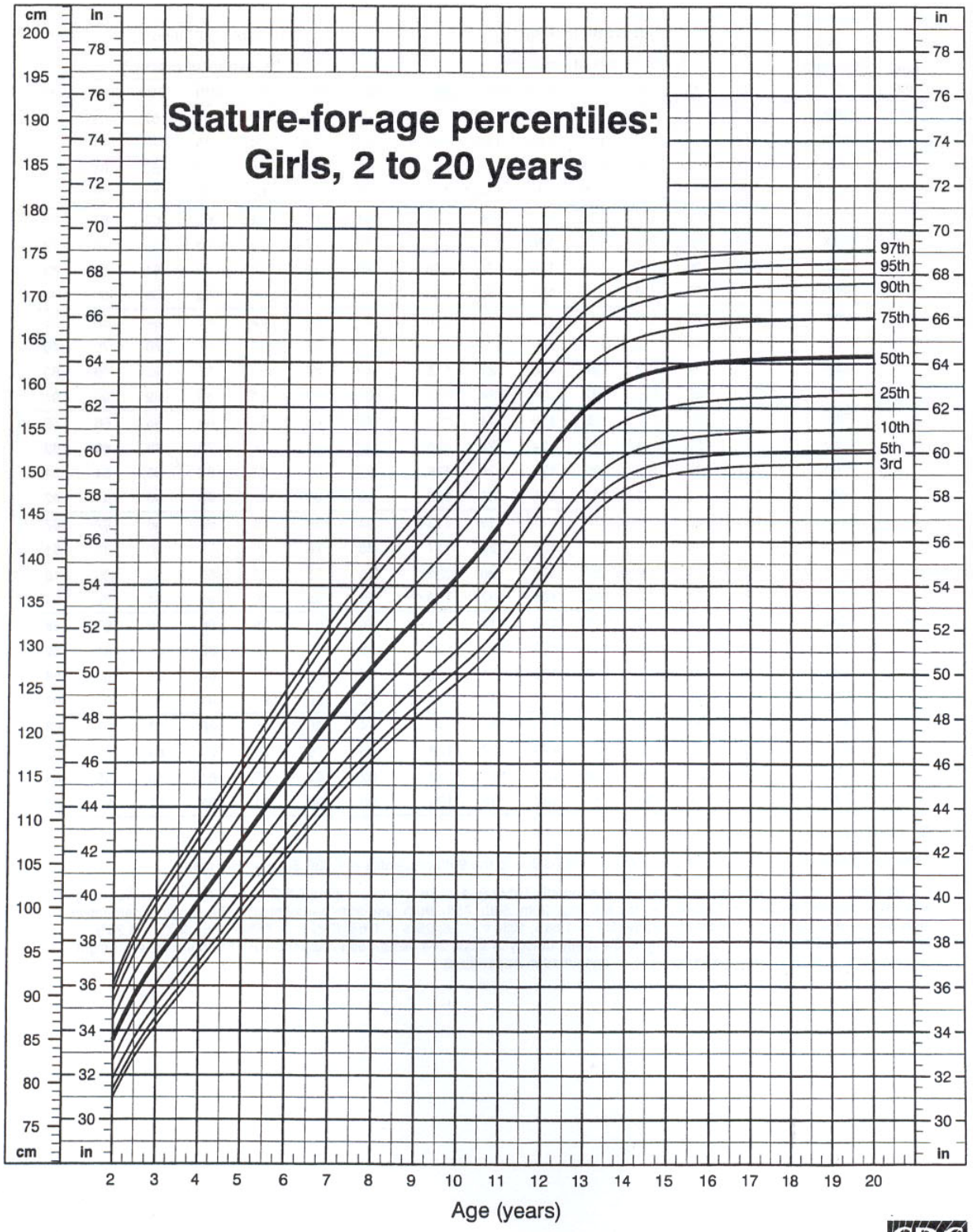
CDC Growth Charts: United States



Published May 30, 2000.
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Blood Pressure Levels for Boys by Age and Height Percentile

Age (Year)	BP Percentile ↓	Systolic BP (mmHg) ← Percentile of Height →							Diastolic BP (mmHg) ← Percentile of Height →						
		5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
1	50th	80	81	83	85	87	88	89	34	35	36	37	38	39	39
	90th	94	95	97	99	100	102	103	49	50	51	52	53	53	54
	95th	98	99	101	103	104	106	106	54	54	55	56	57	58	58
	99th	105	106	108	110	112	113	114	61	62	63	64	65	66	66
2	50th	84	85	87	88	90	92	92	39	40	41	42	43	44	44
	90th	97	99	100	102	104	105	106	54	55	56	57	58	58	59
	95th	101	102	104	106	108	109	110	59	59	60	61	62	63	63
	99th	109	110	111	113	115	117	117	66	67	68	69	70	71	71
3	50th	86	87	89	91	93	94	95	44	44	45	46	47	48	48
	90th	100	101	103	105	107	108	109	59	59	60	61	62	63	63
	95th	104	105	107	109	110	112	113	63	63	64	65	66	67	67
	99th	111	112	114	116	118	119	120	71	71	72	73	74	75	75
4	50th	88	89	91	93	95	96	97	47	48	49	50	51	51	52
	90th	102	103	105	107	109	110	111	62	63	64	65	66	66	67
	95th	106	107	109	111	112	114	115	66	67	68	69	70	71	71
	99th	113	114	116	118	120	121	122	74	75	76	77	78	78	79
5	50th	90	91	93	95	96	98	98	50	51	52	53	54	55	55
	90th	104	105	106	108	110	111	112	65	66	67	68	69	69	70
	95th	108	109	110	112	114	115	116	69	70	71	72	73	74	74
	99th	115	116	118	120	121	123	123	77	78	79	80	81	81	82
6	50th	91	92	94	96	98	99	100	53	53	54	55	56	57	57
	90th	105	106	108	110	111	113	113	68	68	69	70	71	72	72
	95th	109	110	112	114	115	117	117	72	72	73	74	75	76	76
	99th	116	117	119	121	123	124	125	80	80	81	82	83	84	84
7	50th	92	94	95	97	99	100	101	55	55	56	57	58	59	59
	90th	106	107	109	111	113	114	115	70	70	71	72	73	74	74
	95th	110	111	113	115	117	118	119	74	74	75	76	77	78	78
	99th	117	118	120	122	124	125	126	82	82	83	84	85	86	86
8	50th	94	95	97	99	100	102	102	56	57	58	59	60	60	61
	90th	107	109	110	112	114	115	116	71	72	72	73	74	75	76
	95th	111	112	114	116	118	119	120	75	76	77	78	79	79	80
	99th	119	120	122	123	125	127	127	83	84	85	86	87	87	88
9	50th	95	96	98	100	102	103	104	57	58	59	60	61	61	62
	90th	109	110	112	114	115	117	118	72	73	74	75	76	76	77
	95th	113	114	116	118	119	121	121	76	77	78	79	80	81	81
	99th	120	121	123	125	127	128	129	84	85	86	87	88	88	89
10	50th	97	98	100	102	103	105	106	58	59	60	61	61	62	63
	90th	111	112	114	115	117	119	119	73	73	74	75	76	77	78
	95th	115	116	117	119	121	122	123	77	78	79	80	81	81	82
	99th	122	123	125	127	128	130	130	85	86	86	88	88	89	90

Blood Pressure Levels for Boys by Age and Height Percentile (Continued)

Age (Year)	BP Percentile ↓	Systolic BP (mmHg) ← Percentile of Height →							Diastolic BP (mmHg) ← Percentile of Height →						
		5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
11	50th	99	100	102	104	105	107	107	59	59	60	61	62	63	63
	90th	113	114	115	117	119	120	121	74	74	75	76	77	78	78
	95th	117	118	119	121	123	124	125	78	78	79	80	81	82	82
	99th	124	125	127	129	130	132	132	86	86	87	88	89	90	90
12	50th	101	102	104	106	108	109	110	59	60	61	62	63	63	64
	90th	115	116	118	120	121	123	123	74	75	75	76	77	78	79
	95th	119	120	122	123	125	127	127	78	79	80	81	82	82	83
	99th	126	127	129	131	133	134	135	86	87	88	89	90	90	91
13	50th	104	105	106	108	110	111	112	60	60	61	62	63	64	64
	90th	117	118	120	122	124	125	126	75	75	76	77	78	79	79
	95th	121	122	124	126	128	129	130	79	79	80	81	82	83	83
	99th	128	130	131	133	135	136	137	87	87	88	89	90	91	91
14	50th	106	107	109	111	113	114	115	60	61	62	63	64	65	65
	90th	120	121	123	125	126	128	128	75	76	77	78	79	79	80
	95th	124	125	127	128	130	132	132	80	80	81	82	83	84	84
	99th	131	132	134	136	138	139	140	87	88	89	90	91	92	92
15	50th	109	110	112	113	115	117	117	61	62	63	64	65	66	66
	90th	122	124	125	127	129	130	131	76	77	78	79	80	80	81
	95th	126	127	129	131	133	134	135	81	81	82	83	84	85	85
	99th	134	135	136	138	140	142	142	88	89	90	91	92	93	93
16	50th	111	112	114	116	118	119	120	63	63	64	65	66	67	67
	90th	125	126	128	130	131	133	134	78	78	79	80	81	82	82
	95th	129	130	132	134	135	137	137	82	83	83	84	85	86	87
	99th	136	137	139	141	143	144	145	90	90	91	92	93	94	94
17	50th	114	115	116	118	120	121	122	65	66	66	67	68	69	70
	90th	127	128	130	132	134	135	136	80	80	81	82	83	84	84
	95th	131	132	134	136	138	139	140	84	85	86	87	87	88	89
	99th	139	140	141	143	145	146	147	92	93	93	94	95	96	97

BP, blood pressure

* The 90th percentile is 1.28 SD, 95th percentile is 1.645 SD, and the 99th percentile is 2.326 SD over the mean.

For research purposes, the standard deviations in Appendix Table B–1 allow one to compute BP Z-scores and percentiles for boys with height percentiles given in Table 3 (i.e., the 5th,10th, 25th, 50th, 75th, 90th, and 95th percentiles). These height percentiles must be converted to height Z-scores given by (5% = -1.645; 10% = -1.28; 25% = -0.68; 50% = 0; 75% = 0.68; 90% = 1.28%; 95% = 1.645) and then computed according to the methodology in steps 2–4 described in Appendix B. For children with height percentiles other than these, follow steps 1–4 as described in Appendix B.

Blood Pressure Levels for Girls by Age and Height Percentile

Age (Year)	BP Percentile ↓	Systolic BP (mmHg) ← Percentile of Height →							Diastolic BP (mmHg) ← Percentile of Height →						
		5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
1	50th	83	84	85	86	88	89	90	38	39	39	40	41	41	42
	90th	97	97	98	100	101	102	103	52	53	53	54	55	55	56
	95th	100	101	102	104	105	106	107	56	57	57	58	59	59	60
	99th	108	108	109	111	112	113	114	64	64	65	65	66	67	67
2	50th	85	85	87	88	89	91	91	43	44	44	45	46	46	47
	90th	98	99	100	101	103	104	105	57	58	58	59	60	61	61
	95th	102	103	104	105	107	108	109	61	62	62	63	64	65	65
	99th	109	110	111	112	114	115	116	69	69	70	70	71	72	72
3	50th	86	87	88	89	91	92	93	47	48	48	49	50	50	51
	90th	100	100	102	103	104	106	106	61	62	62	63	64	64	65
	95th	104	104	105	107	108	109	110	65	66	66	67	68	68	69
	99th	111	111	113	114	115	116	117	73	73	74	74	75	76	76
4	50th	88	88	90	91	92	94	94	50	50	51	52	52	53	54
	90th	101	102	103	104	106	107	108	64	64	65	66	67	67	68
	95th	105	106	107	108	110	111	112	68	68	69	70	71	71	72
	99th	112	113	114	115	117	118	119	76	76	76	77	78	79	79
5	50th	89	90	91	93	94	95	96	52	53	53	54	55	55	56
	90th	103	103	105	106	107	109	109	66	67	67	68	69	69	70
	95th	107	107	108	110	111	112	113	70	71	71	72	73	73	74
	99th	114	114	116	117	118	120	120	78	78	79	79	80	81	81
6	50th	91	92	93	94	96	97	98	54	54	55	56	56	57	58
	90th	104	105	106	108	109	110	111	68	68	69	70	70	71	72
	95th	108	109	110	111	113	114	115	72	72	73	74	74	75	76
	99th	115	116	117	119	120	121	122	80	80	80	81	82	83	83
7	50th	93	93	95	96	97	99	99	55	56	56	57	58	58	59
	90th	106	107	108	109	111	112	113	69	70	70	71	72	72	73
	95th	110	111	112	113	115	116	116	73	74	74	75	76	76	77
	99th	117	118	119	120	122	123	124	81	81	82	82	83	84	84
8	50th	95	95	96	98	99	100	101	57	57	57	58	59	60	60
	90th	108	109	110	111	113	114	114	71	71	71	72	73	74	74
	95th	112	112	114	115	116	118	118	75	75	75	76	77	78	78
	99th	119	120	121	122	123	125	125	82	82	83	83	84	85	86
9	50th	96	97	98	100	101	102	103	58	58	58	59	60	61	61
	90th	110	110	112	113	114	116	116	72	72	72	73	74	75	75
	95th	114	114	115	117	118	119	120	76	76	76	77	78	79	79
	99th	121	121	123	124	125	127	127	83	83	84	84	85	86	87
10	50th	98	99	100	102	103	104	105	59	59	59	60	61	62	62
	90th	112	112	114	115	116	118	118	73	73	73	74	75	76	76
	95th	116	116	117	119	120	121	122	77	77	77	78	79	80	80
	99th	123	123	125	126	127	129	129	84	84	85	86	86	87	88

Blood Pressure Levels for Girls by Age and Height Percentile (Continued)

Age (Year)	BP Percentile ↓	Systolic BP (mmHg) ← Percentile of Height →							Diastolic BP (mmHg) ← Percentile of Height →						
		5th	10th	25th	50th	75th	90th	95th	5th	10th	25th	50th	75th	90th	95th
11	50th	100	101	102	103	105	106	107	60	60	60	61	62	63	63
	90th	114	114	116	117	118	119	120	74	74	74	75	76	77	77
	95th	118	118	119	121	122	123	124	78	78	78	79	80	81	81
	99th	125	125	126	128	129	130	131	85	85	86	87	87	88	89
12	50th	102	103	104	105	107	108	109	61	61	61	62	63	64	64
	90th	116	116	117	119	120	121	122	75	75	75	76	77	78	78
	95th	119	120	121	123	124	125	126	79	79	79	80	81	82	82
	99th	127	127	128	130	131	132	133	86	86	87	88	88	89	90
13	50th	104	105	106	107	109	110	110	62	62	62	63	64	65	65
	90th	117	118	119	121	122	123	124	76	76	76	77	78	79	79
	95th	121	122	123	124	126	127	128	80	80	80	81	82	83	83
	99th	128	129	130	132	133	134	135	87	87	88	89	89	90	91
14	50th	106	106	107	109	110	111	112	63	63	63	64	65	66	66
	90th	119	120	121	122	124	125	125	77	77	77	78	79	80	80
	95th	123	123	125	126	127	129	129	81	81	81	82	83	84	84
	99th	130	131	132	133	135	136	136	88	88	89	90	90	91	92
15	50th	107	108	109	110	111	113	113	64	64	64	65	66	67	67
	90th	120	121	122	123	125	126	127	78	78	78	79	80	81	81
	95th	124	125	126	127	129	130	131	82	82	82	83	84	85	85
	99th	131	132	133	134	136	137	138	89	89	90	91	91	92	93
16	50th	108	108	110	111	112	114	114	64	64	65	66	66	67	68
	90th	121	122	123	124	126	127	128	78	78	79	80	81	81	82
	95th	125	126	127	128	130	131	132	82	82	83	84	85	85	86
	99th	132	133	134	135	137	138	139	90	90	90	91	92	93	93
17	50th	108	109	110	111	113	114	115	64	65	65	66	67	67	68
	90th	122	122	123	125	126	127	128	78	79	79	80	81	81	82
	95th	125	126	127	129	130	131	132	82	83	83	84	85	85	86
	99th	133	133	134	136	137	138	139	90	90	91	91	92	93	93

BP, blood pressure

* The 90th percentile is 1.28 SD, 95th percentile is 1.645 SD, and the 99th percentile is 2.326 SD over the mean.

For research purposes, the standard deviations in Appendix Table B–1 allow one to compute BP Z-scores and percentiles for girls with height percentiles given in Table 4 (i.e., the 5th,10th, 25th, 50th, 75th, 90th, and 95th percentiles). These height percentiles must be converted to height Z-scores given by (5% = -1.645; 10% = -1.28; 25% = -0.68; 50% = 0; 75% = 0.68; 90% = 1.28%; 95% = 1.645) and then computed according to the methodology in steps 2–4 described in Appendix B. For children with height percentiles other than these, follow steps 1–4 as described in Appendix B.

TREATMENT OF CHILDHOOD HYPERTENSION

- Weight reduction is the primary therapy for obesity-related hypertension. Prevention of excess or abnormal weight gain will limit future increases in blood pressure.

- It is also recommended that regular physical activity be incorporated in the child's lifestyle. Encouraging children to become more physically active will improve efforts of weight management and may prevent an excess increase in blood pressure over time.

- Recommend dietary modification in children and adolescents who have blood pressure levels in the pre-hypertensive range as well as those with hypertension. The DASH (Dietary Approaches to Stopping Hypertension) should be considered (see appendix).

- Family involvement and support based intervention improves success.

- Smoking cessation should be recommended if the child or adolescent smokes.

- Indications for antihypertensive drug therapy in children include secondary hypertension and insufficient response to lifestyle modifications.

- Pharmacologic therapy, when indicated, should be initiated with a single drug. Acceptable drug classes for use in children include ACE inhibitors, angiotensin-receptor blockers, β-blockers, calcium channel blockers, and diuretics.

- Recent clinical trials have expanded the number of drugs that have pediatric dosing information. Updated dosing recommendations for many of the newer drugs are available from the producing pharmaceutical company.

APPENDIX

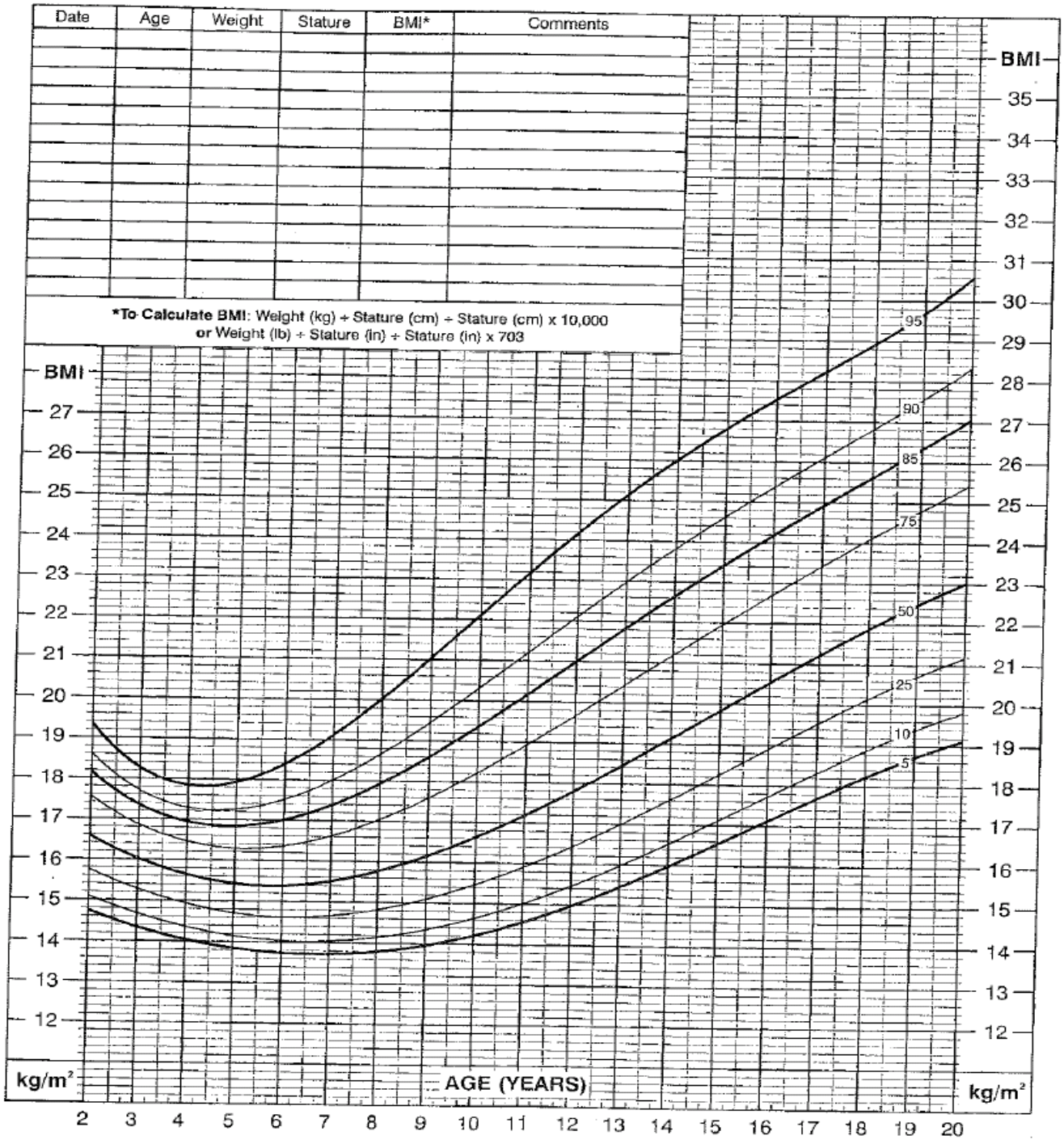
2 to 20 years: Boys
Body mass index-for-age percentiles

NAME _____

RECORD # _____

Date	Age	Weight	Stature	BMI*	Comments

*To Calculate BMI: Weight (kg) ÷ Stature (cm) ÷ Stature (cm) x 10,000
or Weight (lb) ÷ Stature (in) ÷ Stature (in) x 703



Published May 30, 2000 (modified 10/16/00).
SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000).
http://www.cdc.gov/growthcharts

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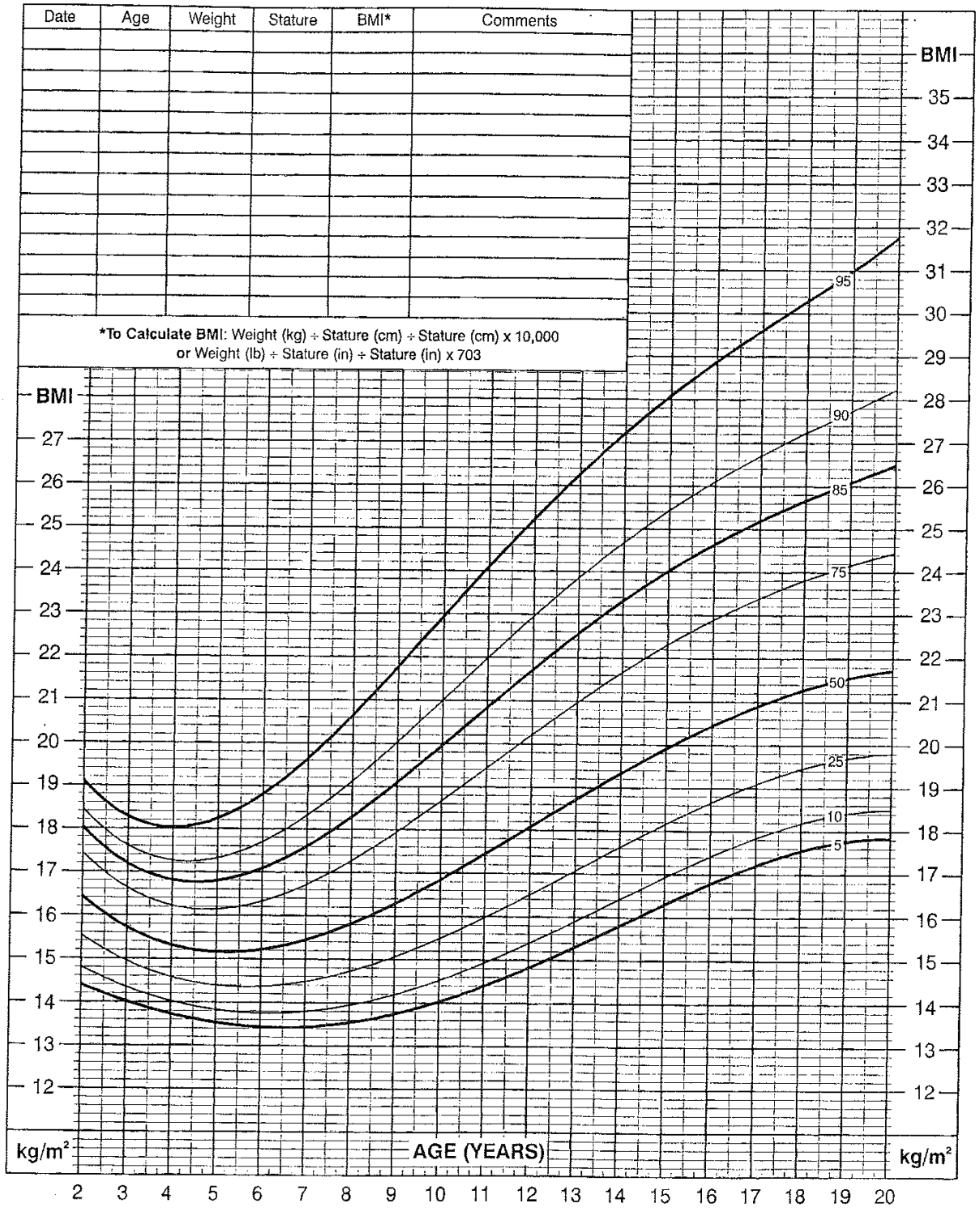
2 to 20 years: Girls
Body mass index-for-age percentiles

NAME _____

RECORD # _____

Date	Age	Weight	Stature	BMI*	Comments

*To Calculate BMI: Weight (kg) ÷ Stature (cm) ÷ Stature (cm) x 10,000
or Weight (lb) ÷ Stature (in) ÷ Stature (in) x 703



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http://www.cdc.gov/growthcharts

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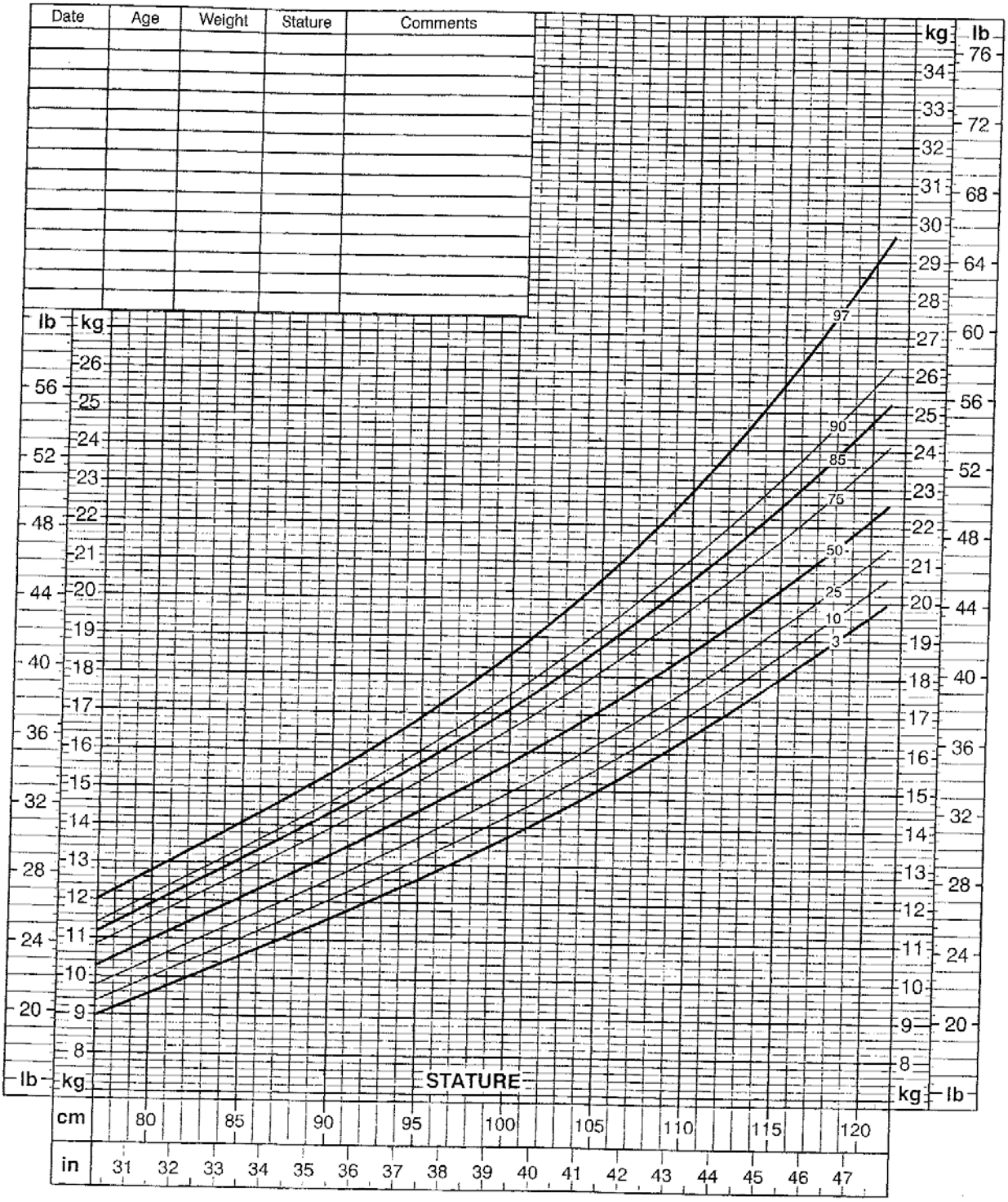
NAME _____

RECORD # _____

Weight-for-stature percentiles: Boys

Date	Age	Weight	Stature	Comments



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http://www.cdc.gov/growthcharts

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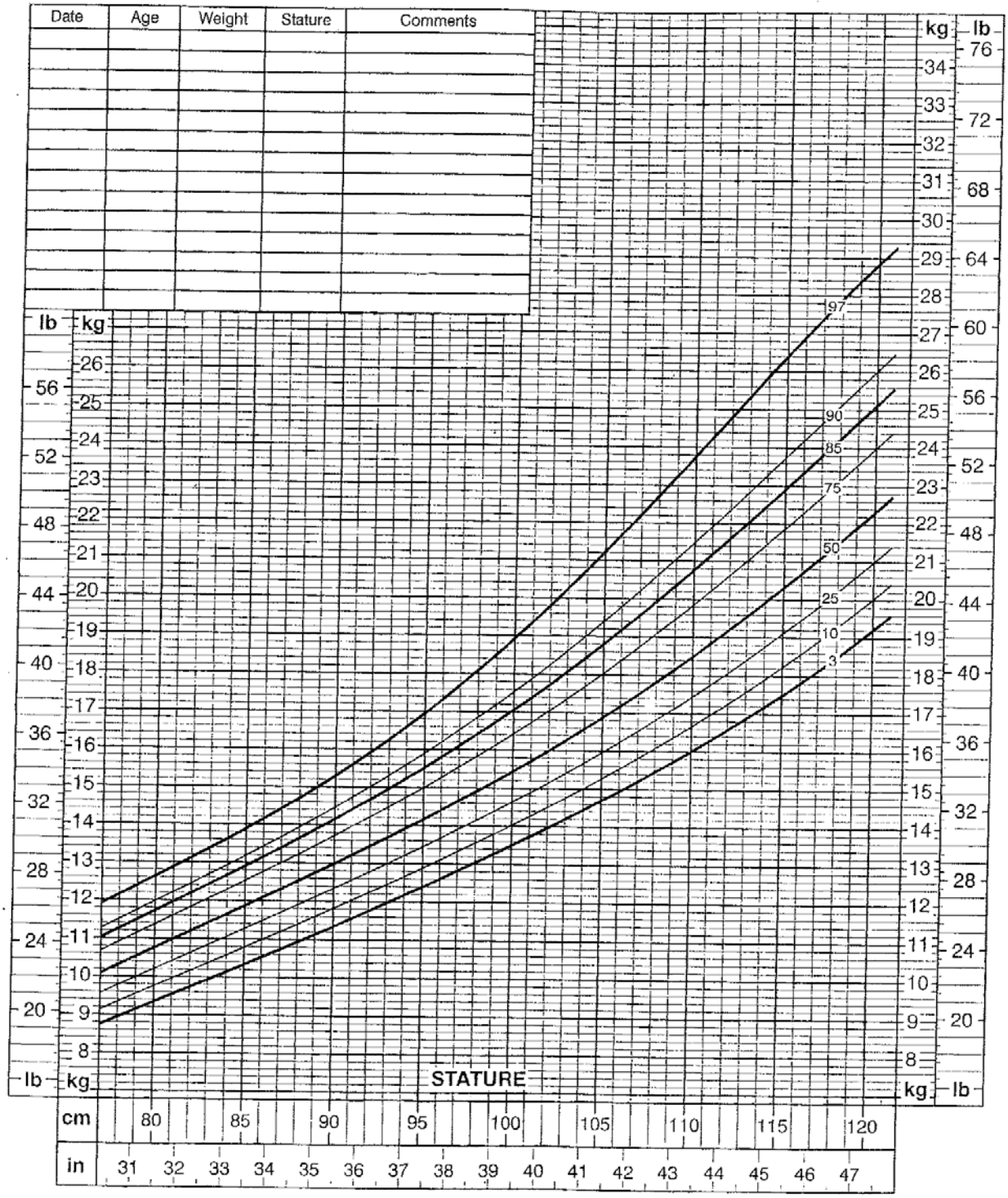
NAME _____

RECORD # _____

Weight-for-stature percentiles: Girls

Date	Age	Weight	Stature	Comments



Published May 30, 2000 (modified 10/16/00).
SOURCE: Developed by the National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000). http://www.cdc.gov/growthcharts

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Pulse Obliteration Technique

TECHNIQUE	RATIONALE
Patient should be seated for five minutes. Patient should refrain from smoking or ingesting caffeine during the 30 minutes prior to the measurement [31, 32].	Vasoconstrictive substances such as nicotine and caffeine may increase the blood pressure [32, 15].
Patient should be sitting up straight with both feet flat on the floor as the procedure is explained and conducted.	Crossing the legs can increase blood pressure. Alteration of body position alters blood pressure. Slouching will elevate both systolic and diastolic levels [8].
Expose the upper right arm by rolling up the sleeve. Jackets or sweaters should be removed. Use the left arm only if there are right arm injuries, trauma, or severe dermatitis.	Sphygmomanometers are designed for right arm measurements [42]. Brachial artery pressure may normally differ between left and right arm measurements by as much as 10 mm Hg and is usually higher in the right arm [6]. Use of right arm for standardization and consistency of readings is recommended. In clinical assessment situations, baseline measurements of both arm pressures are recommended. If a shirt sleeve has been rolled up it can occlude the blood flow in the arm resulting in an erroneously low blood pressure reading. Also, if the stethoscope rubs against the clothing it can create sounds which make it harder to hear the actual blood pressure reading. For the most accurate reading remove clothing from the arm. If the clothing when rolled up the arm is too tight have the patient remove their shirt.
Make certain the center of the upper right arm is at heart level, (approximately the 4th intercostal space) elbow slightly flexed, forearm with the palm facing upwards and supported on a flat surface.	If brachial artery in the upper arm is lower than heart level, blood pressure could increase by as much as 10 mm Hg in both systolic and diastolic readings [31, 26]. If higher than heart level, blood pressure measurement will be as much as 10 mm Hg lower.

The blood pressure cuff should be applied so the cuff is one-inch (about the width of two fingers) above the natural crease (antecubital fossa). The inflatable bladder is centered over the brachial artery (cuffs are usually marked appropriately). Do not place the stethoscope under the cuff.	This space allows proper placement of the stethoscope. If a portion of the head of the stethoscope is placed under the cuff, it may cause uneven cuff pressure and distort the reading [18]. Proper cuff placement also reduces the possibility of bumping the tubing or the cuff.

TECHNIQUE	RATIONALE
Wrap the cuff snugly around the upper arm area.	The bladder of a loosely wrapped cuff will balloon and decrease the effective width causing an elevated reading [8].
Be certain you are using the proper size cuff. Many cuffs are marked inside with a range to ensure appropriate cuff size. When the cuff is applied to the arm, the end of the cuff should fall within the range marked on the cuff. If the cuff does not fit within the range, select a larger size.	If the cuff is too short the reading will be erroneously high and if the cuff is too wide the reading will be erroneously low [17].
Attach cuff to the sphygmomanometer.	
Locate the brachial artery.	
Inflate cuff while palpating the radial artery pulse until the pulse is obliterated [31]. Make a mental note of the pulse obliteration level. This level will closely approximate the systolic blood pressure.	This method eliminates the problem of an auscultatory gap, the temporary disappearance of second phase blood pressure sounds. Phase One Korotkoff sounds are heard over the brachial artery when cuff pressure is high and disappear as pressure is reduced (Phase Two), reappearing at a lower level (Phase Three). If the screener does not know how high to properly inflate the cuff, it is possible the first sounds heard could be the reappearance of sounds in the third phase, not the first phase. This could result in underestimation of systolic blood pressure by as much as 40 mm Hg [31, 5]. The pulse obliteration technique also alerts the screener to irregularities of heart rate which would affect interpretation of blood pressure readings.
	Over-inflation of the cuff may cause a spasm of the vessels, resulting in increased blood pressure peripheral resistance (the resistance by the arterioles to the flow of blood), which creates increased myocardial taxation (work load of the heart) resulting in increased blood pressure[18]. Unnecessary elevations of cuff pressure may also cause pain to the client, resulting in a stress response and an elevated reading [11, 19].

TECHNIQUE	RATIONALE
Calculate peak inflation by adding 30 mm Hg to the level at which the radial pulse is obliterated. Deflate the cuff fully, wait 30 seconds and then re-inflate to the peak inflation level. Example: Pulse Obliteration point 124 mm Hg + 30 Peak Inflation Level 154 mm Hg	The peak inflation rate is 30 mm Hg above the level at which the radial pulse is obliterated in adults and 20 mm Hg above the level at which the radial pulse is obliterated in children.
Allow at least 30 seconds between pulse obliteration and auditory measurement. Instead of deflating the cuff fully and then reinflating after 30 seconds, people who have had more experience and are able to control the valve so that no air escapes from the cuff after pulse obliteration can immediately continue to inflate the cuff to the peak inflation level. This takes some practice to learn how to control the valve so no air escapes.	This will allow for the release of blood that is trapped in the veins [31].
Place the stethoscope over the brachial artery. Avoid allowing the stethoscope to bump the cuff or tubing. Make sure the entire surface of the stethoscope is against the surface of the arm. Apply as little pressure on the head of the stethoscope as possible.	Careful placement of the stethoscope improves hearing the brachial arterial sounds [29]. Heavy pressure distorts the artery and produces sounds heard below diastolic pressure, or may obliterate the sounds entirely [31].
Rapidly inflate the cuff to peak inflation level (with small quick puffs).	An auscultatory gap is more likely to occur if the blood pressure cuff is inflated too slowly [7].
Deflate the cuff by 2 mmHg per second.	If deflation is slower than 2 mm Hg/second venous congestion develops and diastolic reading could be elevated [8]. If deflation is more rapid than 2 mm Hg per second the observer may err in identifying faint sounds either at onset or disappearance of sounds.

TECHNIQUE	RATIONALE
Avoid re-inflating the cuff after deflation has begun.	Venous return will engorge the forearm with blood and produce a loss of clarity of diastolic endpoint [7]. It may also result in a falsely low systolic and elevated diastolic pressure. It may also produce an auscultatory gap, or create spasms [8]. If the cardiac rhythm is irregular, rapid deflation of the cuff upon initial disappearance of sound may result in an elevated diastolic reading [34].
Listen for the onset and disappearance of Korotkoff sounds. Do not be confused by bounces in the column of mercury or of the needle on the aneroid dial – note auditory sounds not visual cues. To make certain the sound is not from an outside source, at least two consecutive beats should be heard as the pressure falls. Continue the deflation at this rate to 10 mm Hg past the disappearance of sound, then deflate rapidly.	

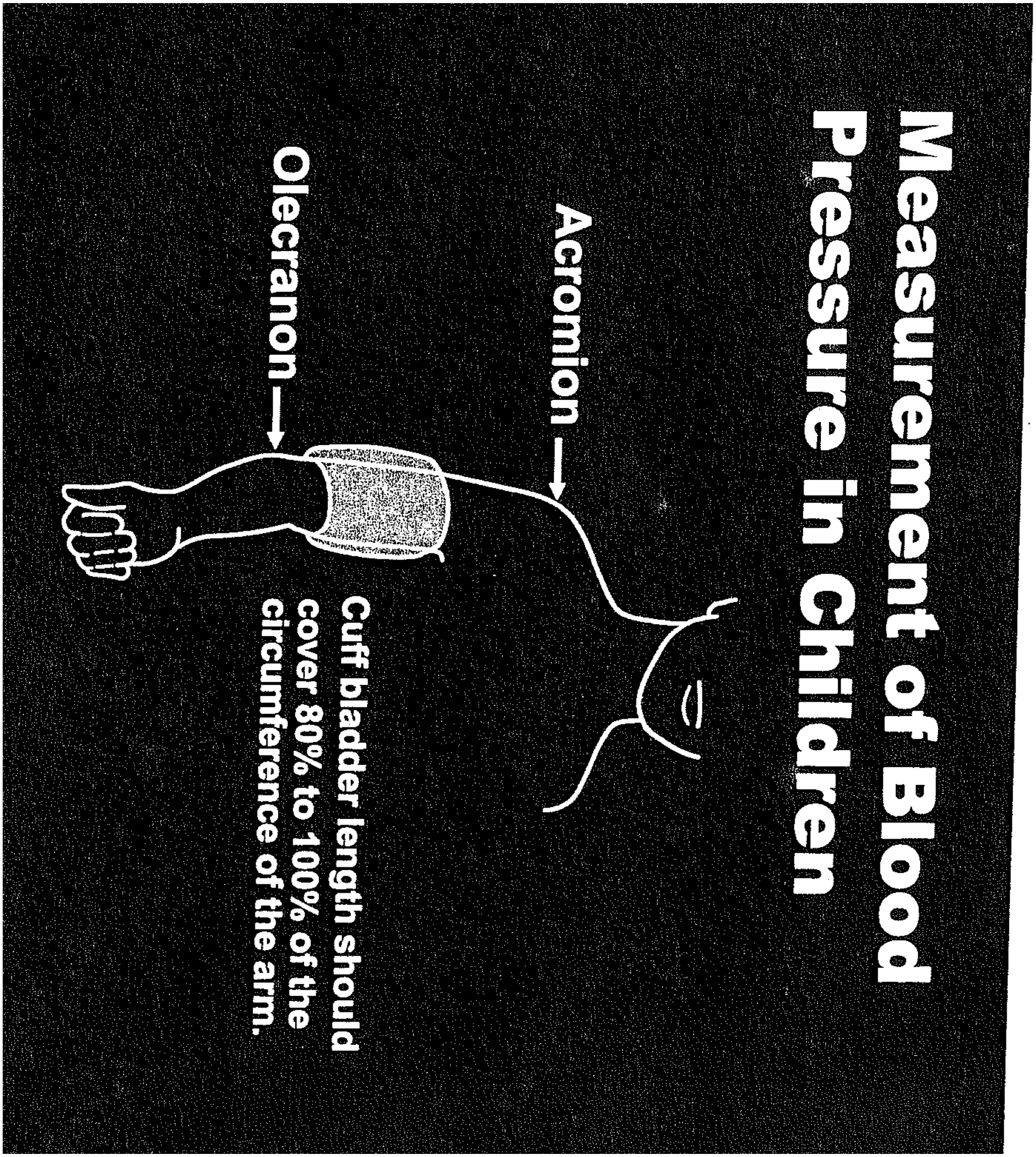
FOLLOWING THE DASH DIET

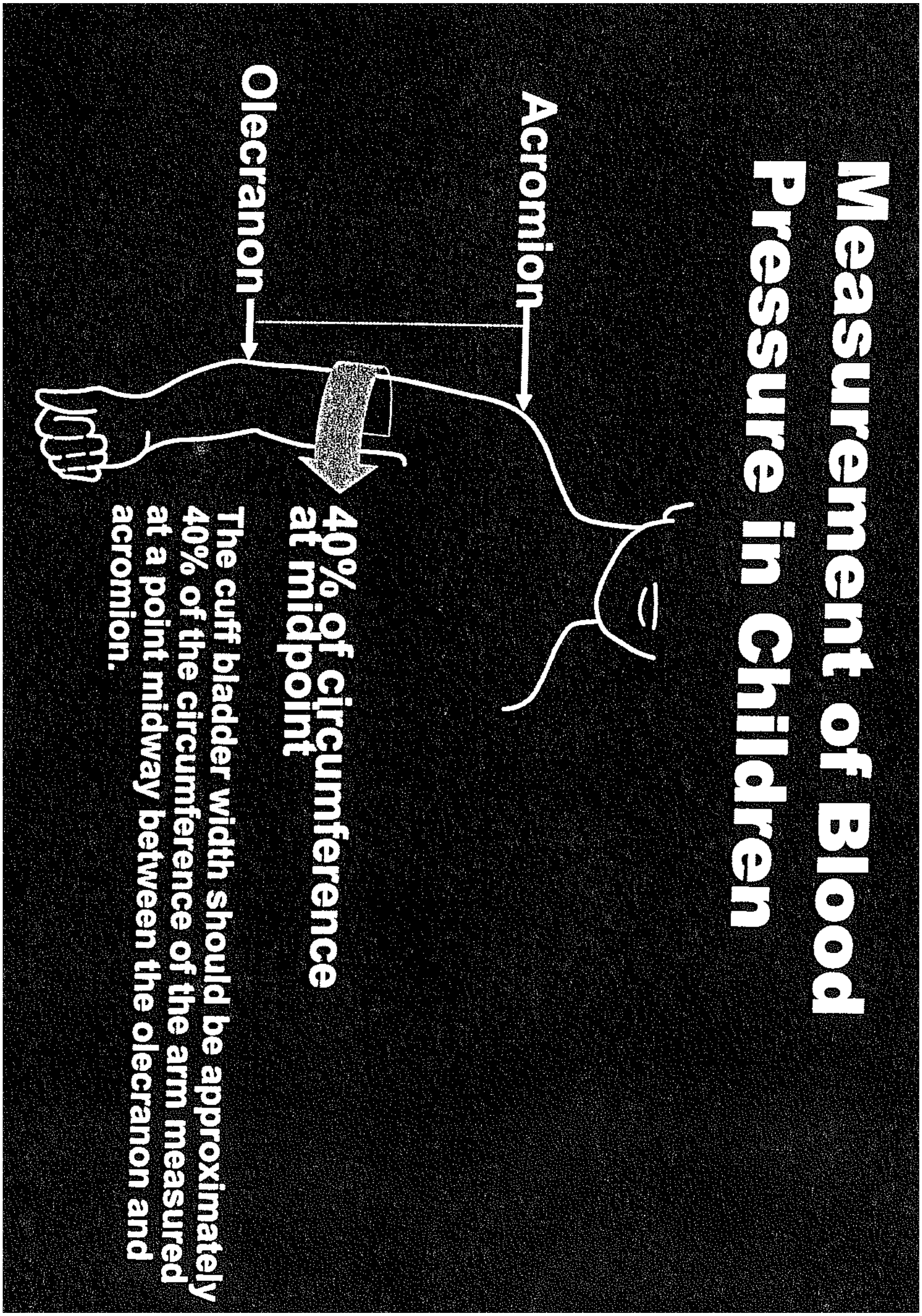
This table provides a list of daily servings of the various food groups and gives examples.

Food Group	Daily Servings	Serving Sizes	Example and Notes	Significance of each food group to the DASH eating plan
Grain and Grain Products	7-8	1 slice bread 1 cup dry cereal 1 /2 cup cooked rice, past or cereal	Whole wheat bread, English muffin, pita bread, bagel, cereals, grits, oatmeal, crackers, unsalted pretzels, and popcorn	Major source of energy and fiber
Vegetables	4-5	1 cup raw leafy vegetable ½ cup cooked vegetable 6 oz 100% vegetable juice	Tomatoes, potatoes, carrots, green peas, squash, broccoli, turnip greens, collards, kale, spinach, artichokes, green beans, lima beans, sweet potatoes	Rich sources of potassium, magnesium and fiber
Fruits	4-5	6 oz 100% fruit juice 1 medium fruit ¼ cup dried fruit ½ cup fresh, frozen or canned fruit	Apricots, bananas, dates, grapes, oranges, orange juice, grapefruit, grapefruit juice, mangoes, melons, peaches, pineapples, prunes, raisins, strawberries, tangerines	Important source of potassium, magnesium, and fiber
Low fat or Fat Free Dairy products	2-3	8 oz milk 1 cup yogurt 1 ½ oz cheese	Fat free (skim) or low fat (1%) milk, fat free or low fat buttermilk, fat free or low fat regular or frozen yogurt, low fat and fat free cheese	Major source of calcium and protein
Meats Poultry and Fish	2 or less	3 oz. Cooked meats, poultry or fish	Select only lean; trim away visible fats; broil roast, or boil instead of frying; remove skin from poultry	Rich sources of protein and magnesium
Nuts, Seeds and Dry Beans	4-5 per week	1/3 cup or 1 ½ oz nuts 2 Tbs or ½ oz seeds ½ cup cooked dry beans	Almonds, filberts, mixed nuts, peanuts, walnuts, sunflower seeds, kidney beans, lentils, peas	Rich sources of energy, magnesium, potassium, protein and fiber
Fats and Oils*	2-3	1 tsp soft margarine 1 Tbsp low fat mayonnaise 2 Tbsp light salad dressing 1 tsp vegetable oil	Soft margarine, low fat mayonnaise, light salad dressing, vegetable oil (such as olive, corn, canola, or safflower)	Besides fats added to foods, remember to choose foods that contain less fat
Sweets	5 per week	1 Tbsp sugar 1 Tbsp jelly or jam ½ oz jelly beans 8 oz lemonade	Maple syrup, sugar, jelly, jam, fruit-flavored gelatin, jelly beans, hard candy, fruit punch, sorbet and ices	Sweets should be low in fat

* Fat content changes serving counts for fats and oils: For example 1 Tbsp of regular salad dressing equals 1 serving; 1 Tbsp of low fat dressing equals ½ serving; 1 Tbsp of a fat free dressing equals 0 servings.

* Another important aspect of the DASH is limiting sodium, or salt in the diet. This is especially important for those watching out for high blood pressure. A sodium intake of 1,500 mg per day provides the greatest reductions.


Measurement of Blood Pressure in Children
Acromion
Olecranon
Cuff bladder length should cover 80% to 100% of the circumference of the arm.


Measurement of Blood Pressure in Children
Acromion
Olecranon
40% of circumference at midpoint
The cuff bladder width should be approximately 40% of the circumference of the arm measured at a point midway between the olecranon and acromion.

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